DER-CAM DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS

ANALYTICS | PLANNING | OPERATIONS

Industry Day and Open House at Berkeley Lab 2016

Presented by
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DEPARTMENT OF ENERGY UNITED STATES OF AMERICA

What is DER-CAM?

Free-access decision support tool for decentralized energy systems

- **Optimal energy supply solutions for buildings and microgrids**
- **Optimal dispatch of existing energy supply technologies in buildings and microgrids**

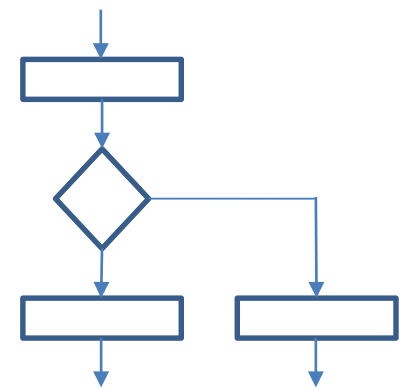
DER-CAM is…

- *A physically-based* ***(economic) optimization model***
  - Find most cost-effective mix of generation and storage + dispatch that minimizes costs / CO_2 emissions
  - Decisions consider load management options such as load shifting, load scheduling, load shedding
  - Constrains force energy balance and technology behavior
  - Takes into account power flow constrains

DER-CAM is not a…

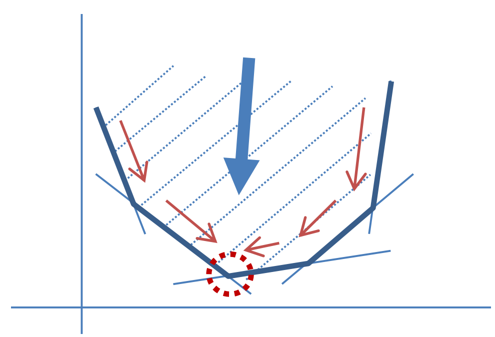
- *Detailed electrical design tool*
- *Simulation model*

Optimization vs. Simulation



Simulation:

- Pre-defined set of rules
  If PV output > 0:
    If Load > 0: serve load;
    Else if Battery SOC < Max: Charge Battery
- Only one possible output per input (not optimal)
- Very fast



Optimization:

- Define boundaries for each variable
  0 <= PV output <= Cap * Irradiation * Eff
- Entire feasible region of possible output
- Define an objective function
  Total Cost = DER Inv. Cost + DER Op. Cost + Util. Cost
- Find the solution in the feasible region that optimizes the objective
- Problems may become very large and take time to solve

What is DER-CAM?

<u>Two main branches</u>

- **Investment and Planning DER-CAM**
  - Considers hourly loads of representative day-types based in historic or simulated data
  - Finds optimal investment decisions for a representative year, or investment timeline up to 20 years in the future
  - Investment decisions are based in a bottom-up approach: optimized dispatch for representative day-types
  - Technologically neutral
- Operations DER-CAM (for Model Predictive Controllers)
  - Considers higher resolution time steps (1 min to 1 hour)
  - Finds optimal dispatch of local energy resources on a week-ahead basis
  - Uses existing load information and weather forecasts to forecast loads
  - Can be used to feed data to a microgrid controller (eg. SCADA Systems)

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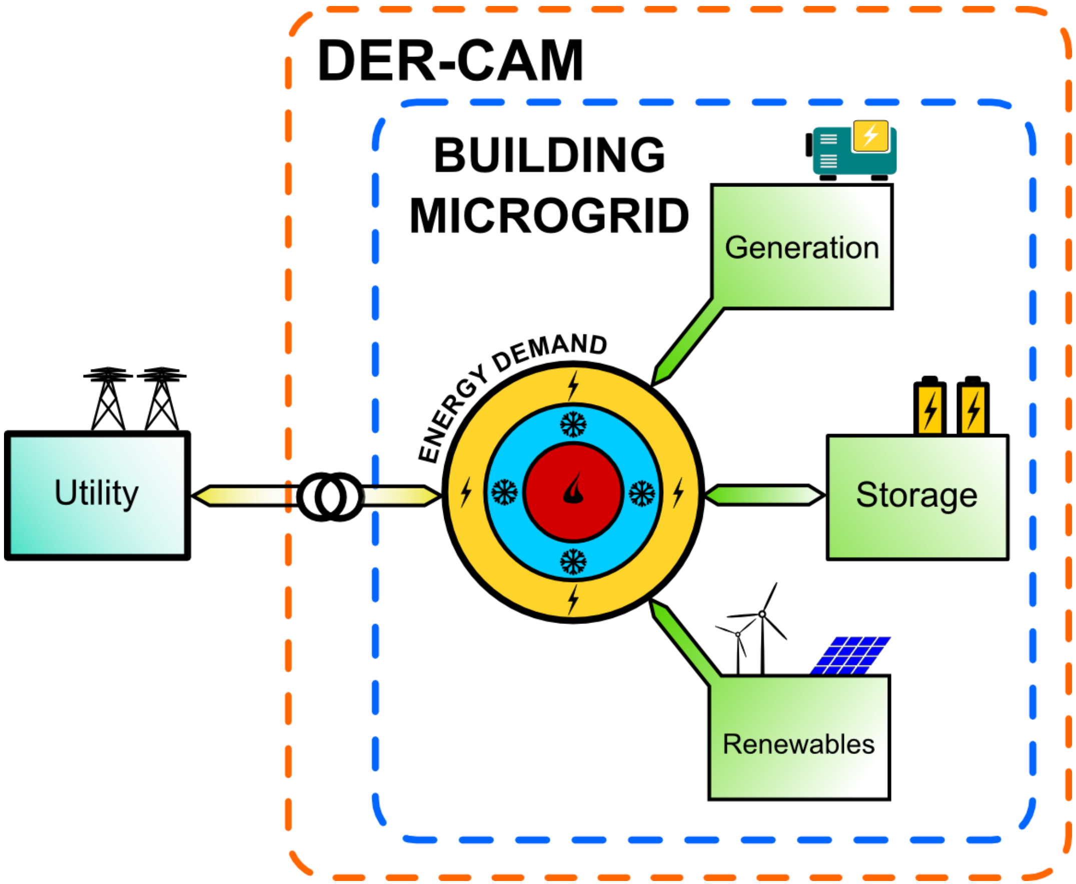

Main Features / Technologies

Distributed Generation

Combustion engines, fuel cells, micro-turbines, CHP, photovoltaic, solar thermal panels, wind turbines

Energy Storage

Stationary storage, electric vehicles, heat storage, cooling storage

Energy Management

Demand response, load shifting, load shedding

Passive technologies

Building shell replacements (windows, doors, insulation)

Roadmap

<u>Recent developments</u>

- Multiple location support
- Power flow
- Fast cloud cover changes
- Tariff database

<u>Work in progress</u>

- Improved battery model
- Improved PV model
- …

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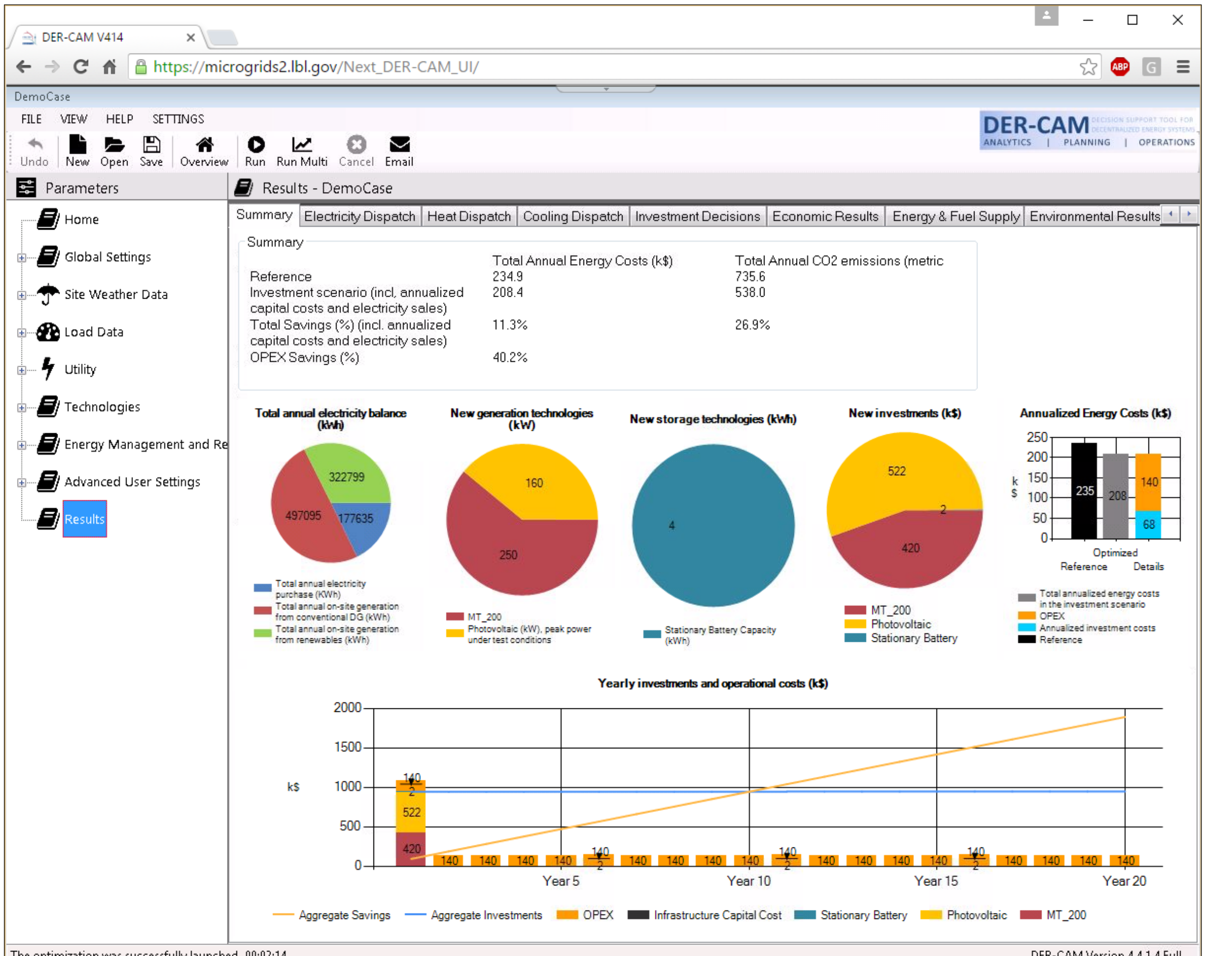
Graphical User Interface



Useful resources

- Load database
- Solar radiation database
- Tariff database
- Template DER data
- Graphical reports
- Investment timeline
- Hourly dispatch
- Breakdown of results

https://building-microgrid.lbl.gov/projects/how-access-der-cam

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Industrial and Government Partners

Universities and National Labs

APPLICATION 1

Using ***Investment & Planning*** ***DER-CAM*** to assess microgrid DER considering prolonged outages

(DER-CAM v4.1.4; GUI v1.4.5)

Establishing Value of Lost Load (VoLL) & Customer Damage Function (CDF)

- VoLL is the value that customers are willing to pay to avoid service interruption.
- May include costs such as lost revenue, wages, value of perishable goods, …
- Used to estimate outage costs.

*Outage Cost ~ Outage Duration * $/kW * Demand*

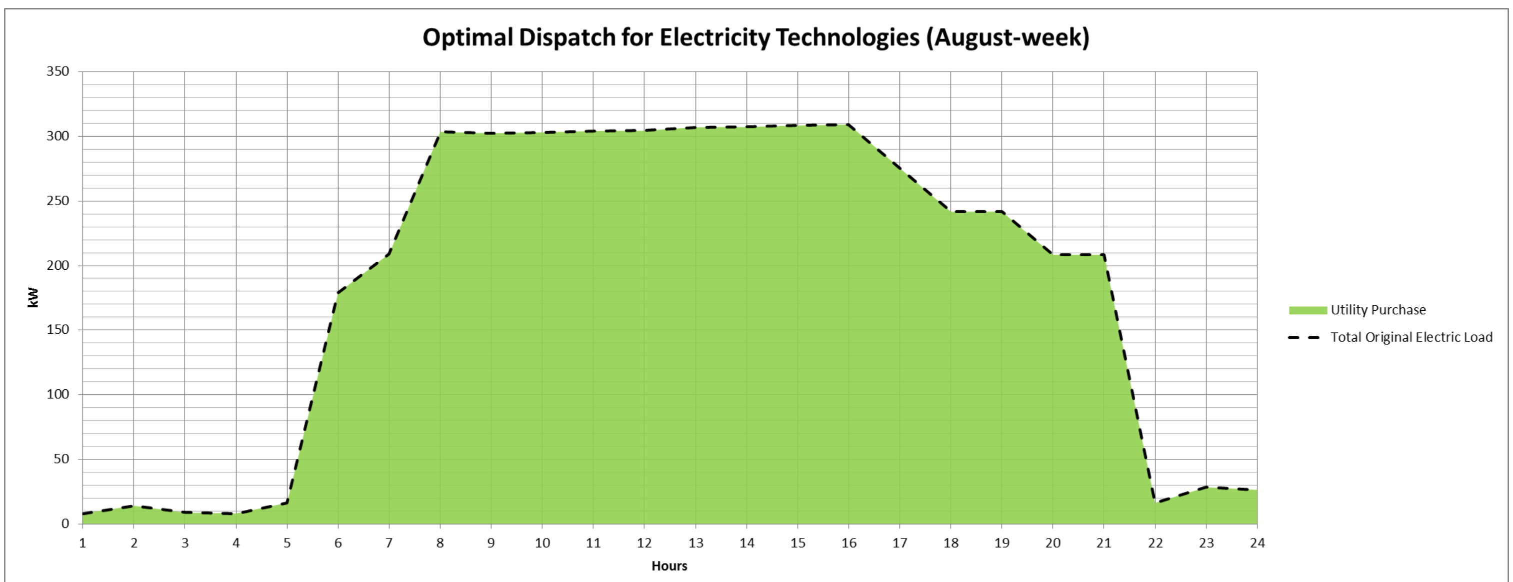
Example: <u>Large Office Building in Baltimore, Maryland</u>

1) Simple Reference Case
2) Outage Reference Case
    - 2 day blackout in August
    - 25% Critical Load (high priority); 50$/kW
    - 75% Non-critical load:
        - 50% medium priority; 15$/kW
        - 25% low priority; 3$/kW
3) Resiliency Investment Case
    - PV and Storage options

SCENARIO 1 : Simple Reference Case

Large Office Building in Baltimore, Maryland

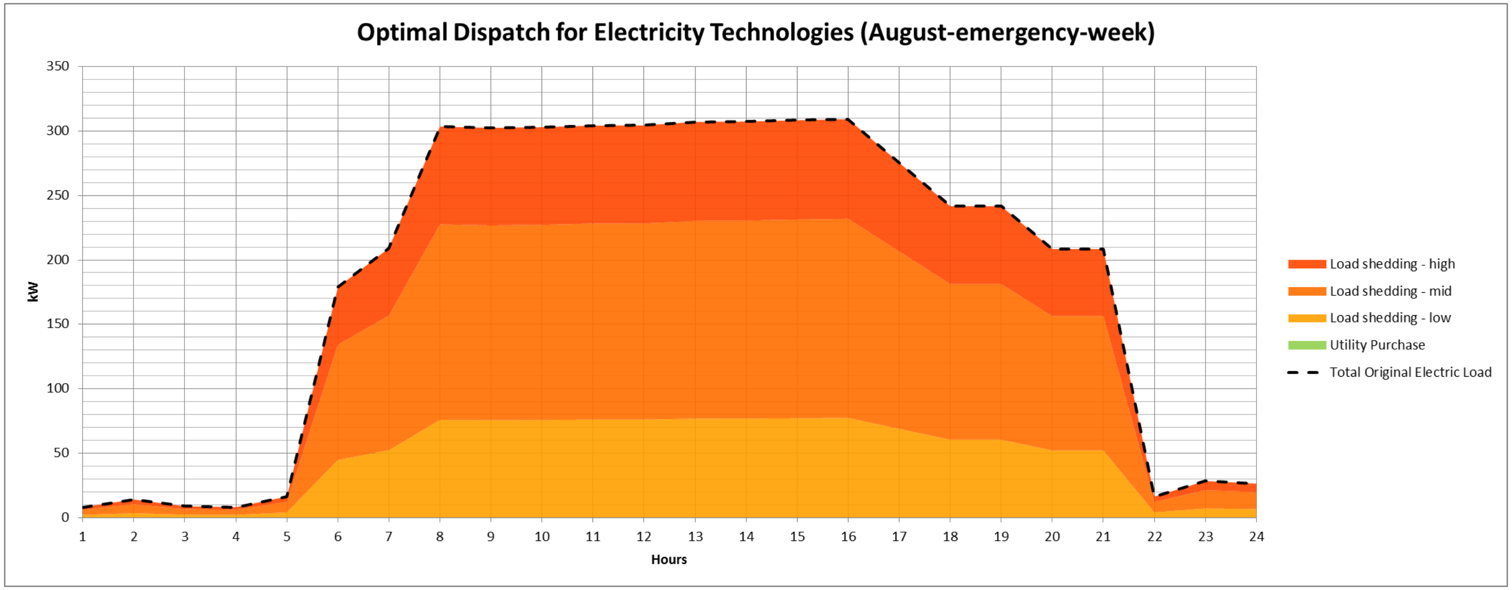
Annual energy costs ~ US$ 123k
All needs are met by utility purchase



SCENARIO 2: Outage Reference Case

Large Office Building in Baltimore, Maryland

Annual energy costs ~ US$ 307k
All load is curtailed

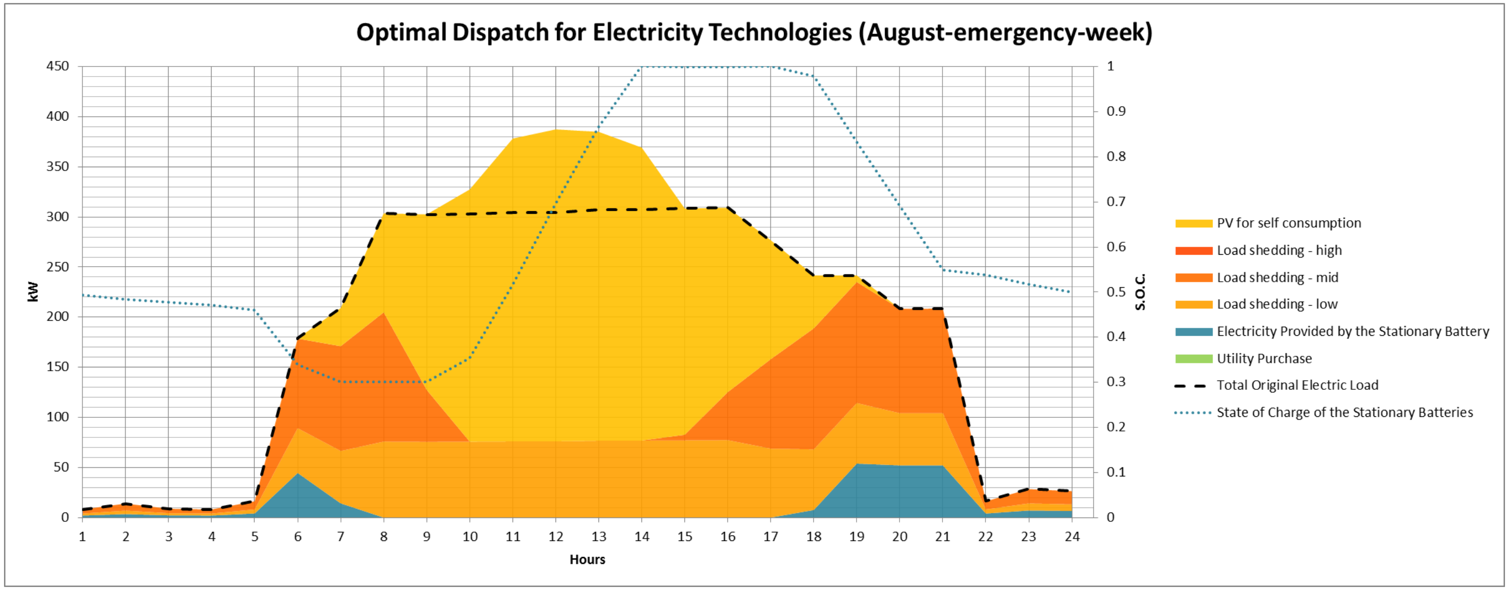


SCENARIO 3: Investment Case considering Outages

Large Office Building in Baltimore, Maryland

~400 kW PV
~400 kWh Battery

Annual energy costs ~ US$ 196k
Some load is still curtailed in the event of a prolonged outage



APPLICATION 2

Using ***Operations*** ***DER-CAM*** to optimize local DER dispatch (MPC)

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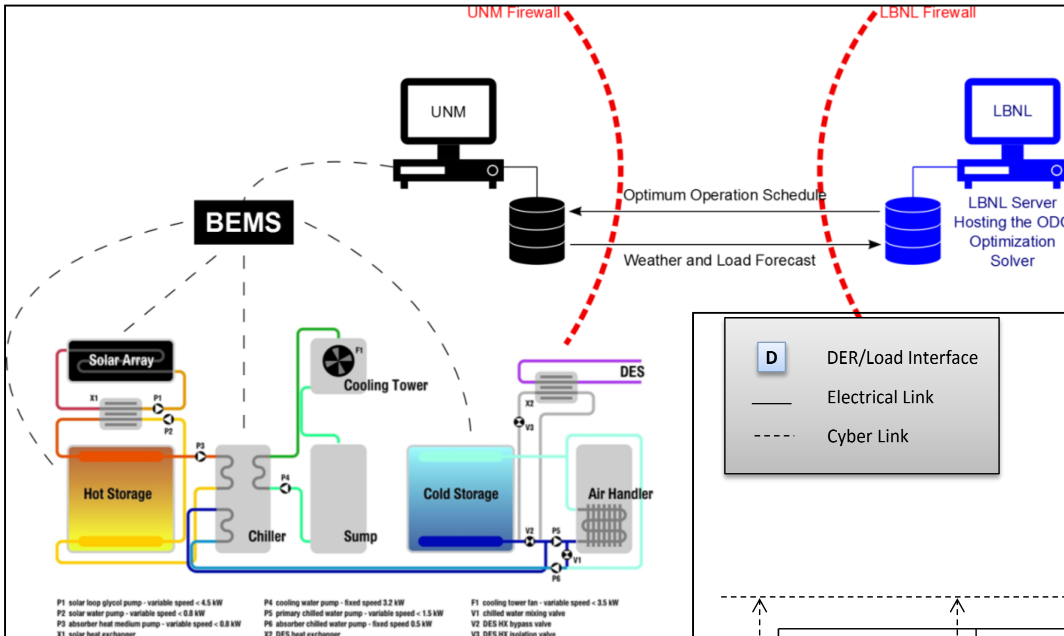
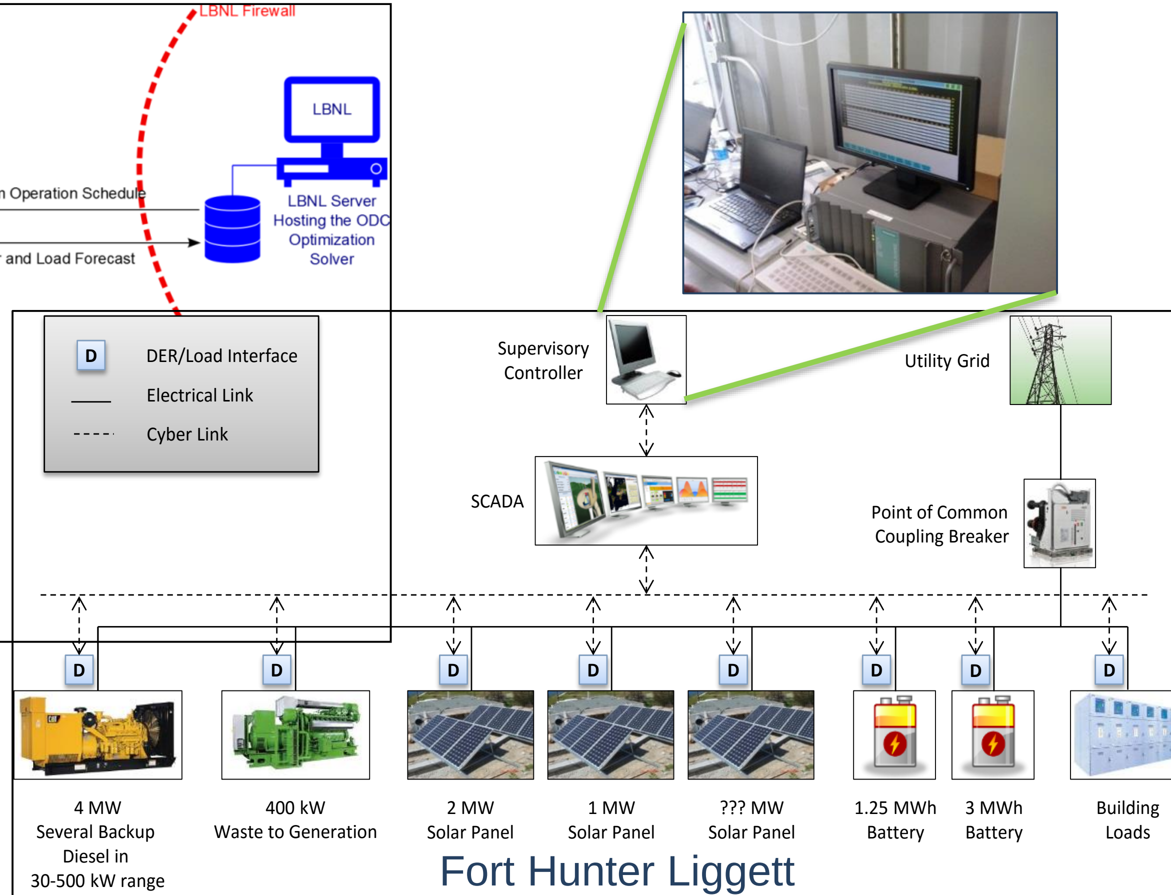
DER-CAM for Optimal microgrid operation

(e.g. used at a Univ. of New Mexico UNM building and Fort Hunter Liggett)



UNM



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USING DER-CAM

Workflow & the GUI

https://building-microgrid.lbl.gov/projects/der-cam

Understanding DER-CAM

Objective function:

Minimize total energy costs (or CO2) such that:

- energy balance is preserved
  - energy supply (t) = energy demand (t)
- technologies operate within physical boundaries
  - power output (t) <= max output
- ***financial constrains are verified***
  - **max payback**: savings obtained by the use of new DER must generate savings that repay investments within the max payback period

⇩

To use DER-CAM, ***at least*** two runs are needed: 1) Base Case; 2) Investment

1) Defining the Base Case

- Energy loads
  - 3 day-types: workday; weekend; peak
- Tariffs
  - time of use energy and power charges
- Existing technologies
  - CHP? PV?
- Load management strategies
  - Load shifting? Demand response?

Run DER-CAM
Save Total Energy Costs
(Total CO2 emissions)

2) Defining the investment run

- New technologies to consider?
- New load management strategies to consider?

Run DER-CAM

Understanding Results

Max Payback

- DER-CAM uses technologies with different lifetimes
- “Max Payback” is a global payback
- Acts as a constrain

Min (total energy costs) such that annual savings / investment <= Max Payback

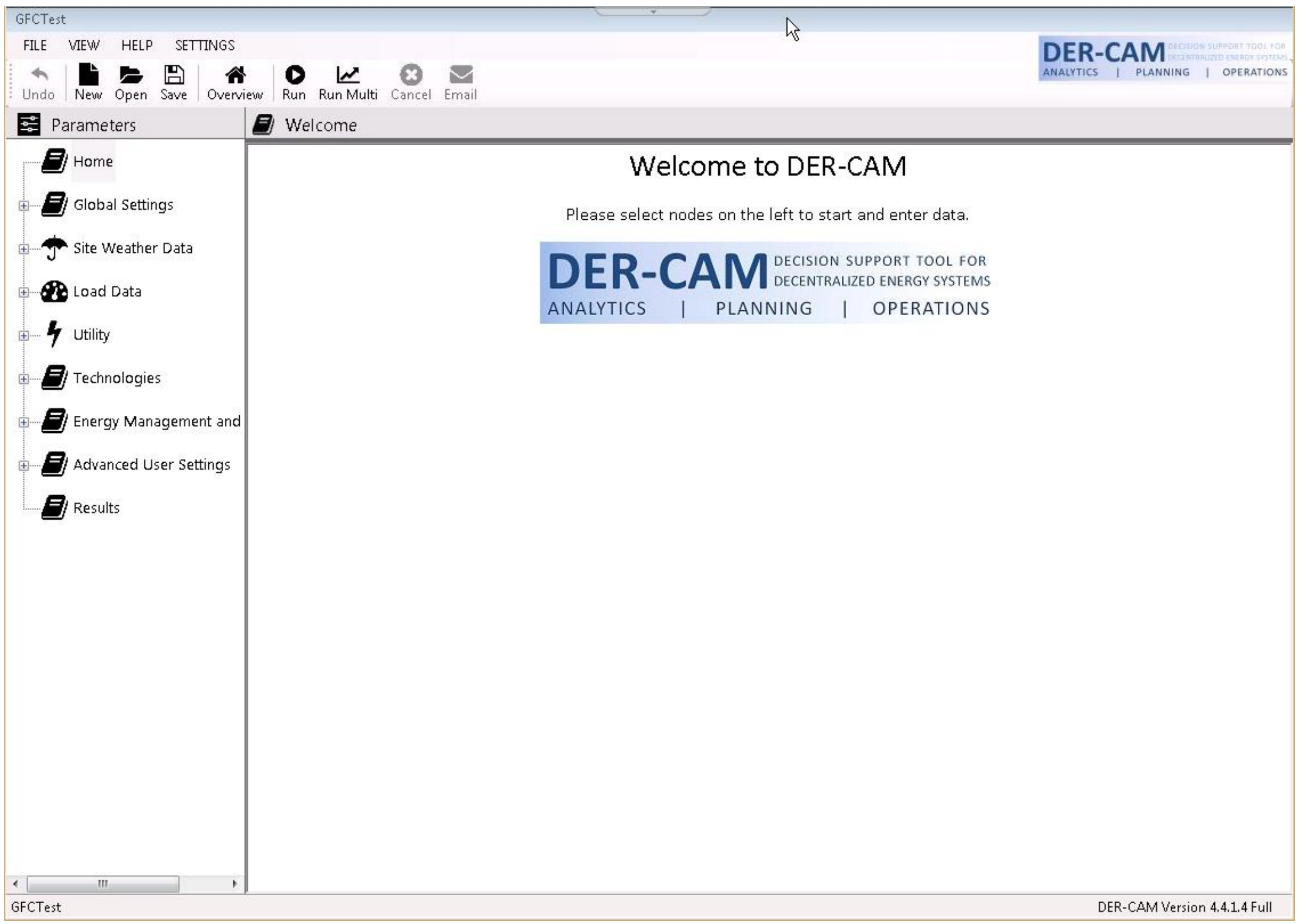
Annualized Capital Costs

- Different technology lifetimes require a method to compare them fairly
- Annualized Capital Cost is the cost per year of owning the equipment
- Total Energy Costs will include Annualized Capital Costs

Optimization algorithm

- “Greedy” approach
  - More of what is most efficient
- Solver precision & problem size
  - Flat solution space
- Indifferent preference
  - Cost vs Benefit

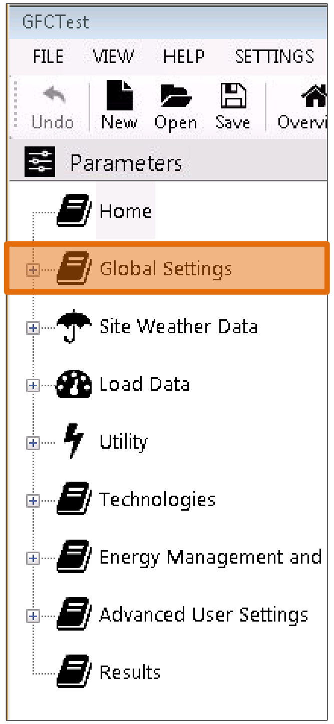
Graphical User Interface v1.4.5



Graphical User Interface

<u>General Options</u>

- Define the type of run
- Define objective function
- Select financial parameters
  - Discount rate
  - Max Payback
  - Reference costs
- Enable desired technology groups

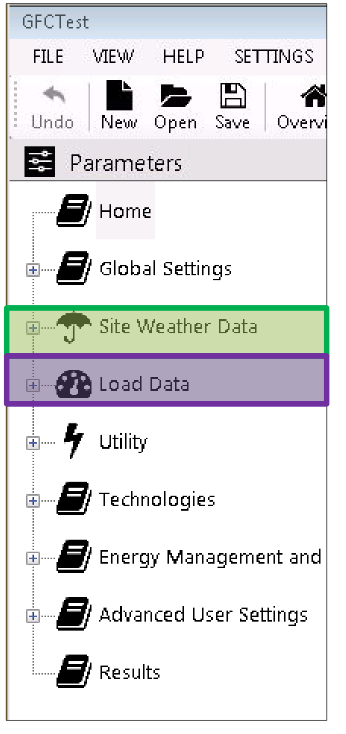


Graphical User Interface

Data collection

- Site / Weather information
  - Solar radiation
  - Ambient temperature

- End-use loads
  - Electricity
  - Cooling
  - Refrigeration
  - Space Heating
  - Water Heating
  - NG loads (cooking)

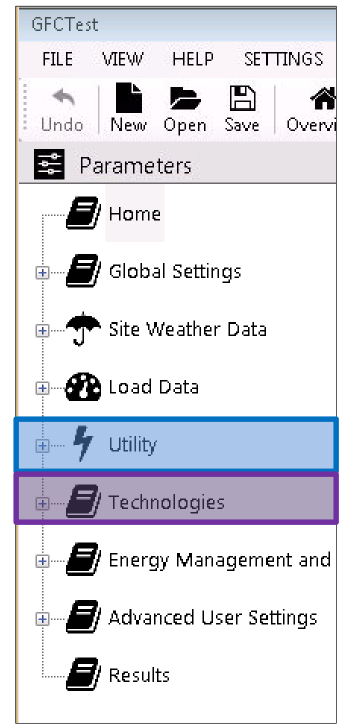


Graphical User Interface

<u>Data collection</u>

- Tariffs
  - Electric Costs
    - Fixed costs
    - Variable costs
      - TOU volumetric and power charges
  - Fuel costs

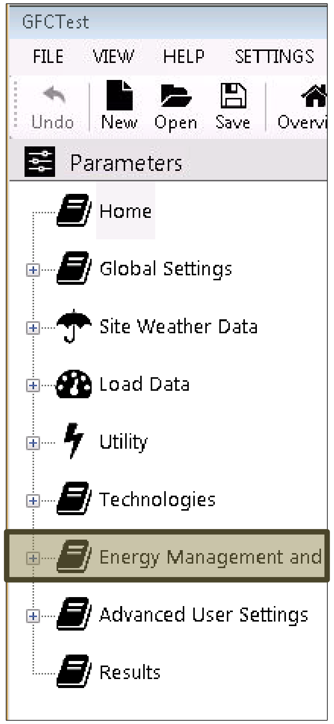
- Technologies
  - Capital costs
  - O&M Costs
  - Rated capacity
  - Efficiency
  - Charge / Discharge rate
  - Heat recovery



Graphical User Interface

<u>Data collection</u>

- Load management options
    - Demand response
    - Directly controllable loads
    - Load shifting
    - Resiliency
        - Outage costs
        - Utility outages
        - Load curtailments



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